Special issue on ‘active behavior in soft matter and mechanobiology’

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This special issue is an outgrowth of the two mini-symposia ‘Soft active materials’ and ‘Mechanobiology of the cell and morphogenesis of living matter’ that took place at the XXII congress of the AIMETA, held in Genova in September 2015.

The goal of the mini-symposia was to gather researchers from different disciplines sharing the interest in a thriving area of contemporary research in Mechanics: *Active Behavior in Soft Matter and Mechanobiology*. Arising in both synthetic and living materials, an active behavior refers to the characteristic property of re-arranging the internal microstructure in response to external, non-mechanical stimuli. Typically, active materials display a complex response driven by their multi-physics and multi-scale nature. A major thrust in research on synthetic materials is devoted to the characterization of their active response, mainly aimed at the development of novel technological applications, especially in the fields of biomedicine and soft-robotics. Examples of such materials include stimuli-responsive gels, ionic polymer-metal composites, liquid crystal elastomers,

electro-active and shape memory polymers. Biological tissues are often taken as model systems for designing active materials, especially because of their remarkable mechanical properties. Recent studies in developmental biology have highlighted the pivotal role of mechanical factors in determining the fate and the evolution of living systems at different characteristic sizes. Indeed, the living cell uses trans-membrane proteins to sense the surrounding environment, transforming the mechanical signal into biochemical activity, which in turn regulates the basic living functions from cell to tissue levels. This interplay between chemo-mechanical cues is at the hearth of Mechanobiology, a discipline at the interface between biology, mathematics and engineering.

This special issue explores these emerging research topics, which have been organized into the following themes: *fluid flow in biological tissues, muscles and mechanobiology, fiber reinforced active and biological tissues, shape control and multiphysics modelling of shape-transformations, fracture in soft materials and biological motility*.

The topic of *fluid flow in biological tissues* is analyzed in the papers [1–4]. The paper by Sacco, Causin, Lelli, and Raimondi applies concepts from mixture theory to the processes of biomass growth for applications in tissue engineering [1]. Grillo, Carfagna, and Federico examine non-Darcian effects in solvent transport in fiber-reinforced biological tissues [2]. A homogenization approach (in particular

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multiscale analysis for materials with double porosity) is used by Penta and Merodio to model vascularized poroelastic materials [3]. Bacca and McMeeking propose an extension of poroelastic models of hydrogels to account for the viscosity of the solvent [4].

Papers [5–7] address the topic of *muscles and mechanobiology*. In particular, Naldi discusses a chemo-mechanical model for the single myofibril in striated muscle contraction exploiting nonlinear nonlocal equations [5]. Ambrosi, Belousov, and Ciarletta review the progress and the open challenges of continuum mechanics theories of morphogenesis in living matter [6]. Sabato, Panzetta, and Netti investigate the regulation dynamics of focal adhesion in cells with respect to their capability of sensing the substrate stiffness [7].

Studies of *fiber reinforced active and biological tissues* are contained in papers [8, 9]. Pandolfi, Gizzi, and Vasta propose a visco-electro-elastic model of tissues reinforced by active fibers based on a statistical description of the fiber distribution [8]. Gilchrist, Murphy, Pierrat, and Saccomandi highlight the role of fiber asymmetry in altering the shear stress distribution and, eventually, causing buckling in arteries [9].

Shape control and multiphysics modelling of shape-transformations are considered in [10–13]. Tomassetti and Varano discuss the helical-to-spiral transition in thin ribbons of nematic elastomers [10]. Curatolo, Gabriele, and Teresi present a constitutive theory for active solids that couples swelling and growth [11]. Using Gamma-convergence, Agostiniani and DeSimone derive plate and rod models for soft active materials such as nematic elastomers [12]. Nardinocchi and Puntel apply the theory of geometric composites to bilayered gel beams to reveal unexpected hardening effects [13].

The topic of *fracture in soft materials* is the focus of the papers [14, 15]. Napoli and Turzi examine the delamination and buckling of a growing elastic sheet subject to capillary adhesion [14]. Lucantonio and Noselli analyze the impact of rate-dependent factors on the toughness of poroelastic composites [15].

Finally, Bagagiolo, Maggistro, and Zoppello deal with the topic of *biological motility* and in particular explore the possibility of achieving locomotion by switching between a slow and a fast actuation strategy [16].

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